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INFLUENCE OF THE ASPEN OVERSTORY ON WHITE SPRUCE GROWTH IN SASKATCHEWAN

by
J. H. Cayford

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Influence of the Aspen Overstory on White Spruce Growth in Saskatchewan

Project MS-167

by

J. H. Cayford*

INTRODUCTION

A mixedwood type consisting mainly of white spruce (*Picea glauca* (Moench) Voss) and trembling aspen (*Populus tremuloides* Michx.) is widely distributed in Western Canada east of the Rockies. In Saskatchewan, where this study was made, about 30 per cent of the presently accessible productive forest is mixedwood (Saskatchewan Department of Natural Resources, 1952-55). It is the main component type of the broad Mixedwood (B.18) Section of the Western Boreal Forest Region (Halliday, 1937) which extends from southwestern Manitoba northwestward across central Saskatchewan and central and northern Alberta. Associated with white spruce and aspen but of lesser importance are black spruce (*Picea mariana* (Mill.) BSP.), jack pine (*Pinus banksiana* Lamb.), balsam fir (*Abies balsamea* (L.) Mill.), balsam poplar (*Populus balsamifera* L.), and white birch (*Betula papyrifera* Marsh).

At the present time, white spruce is the chief lumber species of the Prairie Provinces. However, there is little market for the associated aspen which nevertheless makes a vast demand upon the growth potential of the forest.

Aspen usually forms an overstory in young and intermediate-aged stands, but in older stands the tallest spruce exceed the height of the aspen. Beyond about 70 years of age the percentage of spruce increases as a result of aspen deterioration (Riley, 1952); however, stands up to 110 years of age may still contain a high proportion of aspen.

Observations suggested that white spruce under an aspen canopy are both retarded and damaged. The literature tends to support the observation but provides incomplete information as to what extent the spruce may be affected. In 1953, a study was made to provide additional information about the effect of early aspen dominance on the development of white spruce. Study areas were made available in the vicinity of Prince Albert by the Forestry Branch, Saskatchewan Department of Natural Resources.

REVIEW OF LITERATURE

In Saskatchewan, Kagis (1952) estimated that at least one-third of the possible mature white spruce volume in mixedwood stands was lost because of whipping of the spruce by aspen, and because of suppression.

In the Lake States, Shirley (1941) stated that "it is doubtful whether aspen stands favour the development of conifers at any stage." For mixedwood stands in the same locality, Kittredge and Gevorkiantz (1929) reported that "the most significant fact in the comparative height growth of conifers and aspen is that the conifers.... remain below the aspen and do not overtake it until the aspen stand begins to deteriorate." Robertson (1935) reported that in Ontario aspen litter may retard spruce establishment, while competition from aspen may hinder spruce development.

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* Manitoba-Saskatchewan District Office, Winnipeg, Man.

Various release cutting experiments have been carried out in which the favourable effects of removal of the hardwood overstory have been demonstrated. On the Duck Mountain Forest Reserve in Manitoba, thinning of an aspen overstory increased diameter, height and volume growth of a white spruce understory (Pike, 1948). Additional experiments in New Brunswick (Thomson, 1949) and Ontario (Daly, 1950) showed that the removal of an intolerant hardwood overstory stimulated the diameter growth of the spruce and the balsam fir understory.

On the other hand, Mulloy (1941) wrote the following regarding an intolerant hardwood-conifer stand at Lake Edward, Quebec: "... Intolerant hardwoods do not provide such an intense shade that the conifers are shaded out or become sickly due to suppression; the coniferous understory is healthy." No increase in the height growth of the spruce and balsam understory over a 12-year period followed either complete or partial removal of the aspen and white birch overstory. These contradictory findings obtained in Quebec might be due to a different climate or the presence of different species. Considerable white birch was found in the overstory there, while balsam fir, red spruce (*Picea rubens* Sarg.), and white spruce were the most abundant conifers.

DESCRIPTION OF STUDY AREAS

Five stands (Figure 1) were examined in the Mixedwood (B.18) Section of the Boreal Forest Region. They were composed of mixtures of white spruce and aspen with an occasional scattering of black spruce or white birch. In all except the youngest stand the aspen were becoming decadent and many were dying or had blown down. Dominant white spruce were well formed, but suppressed spruce had damaged leaders, forked tops, and poorly formed boles. White spruce advance growth was present. The stands were situated on upland till soils on sites considered to be representative of those occurring more commonly in that portion of the Forest Section.

It was observed that there was a wide variation in diameters and heights of spruce growing in the same stand. Trees of the same age and on the same site varied from 5 to 14 inches in diameter and from 40 to 85 feet in height, according to the degree of suppression. Diameters and heights of free-growing spruce which had suffered little or no suppression were considerably greater than that of suppressed trees.

Table 1 contains age, diameter and height data for aspen, and for white spruce whose tops had reached the level of the aspen canopy.

TABLE 1.—AGE, DIAMETER AND HEIGHT OF ASPEN AND WHITE SPRUCE

Area	Location	Stump age in years		D.B.H. in inches		Total height in feet	
		Aspen	Spruce	Aspen	Spruce	Aspen	Spruce
Stand 1	Candle Lake.....	70—90	60—75	5—13	5—14	50—70	40—85
Stand 2	Candle Lake.....	70—85	65—75	6—11	5—14	50—65	40—75
Stand 3	Candle Lake.....	55—65	55—60	6—10	5—11	40—60	45—70
Stand 4	Big River.....	85—100	75—85	7—11	6—13	65—70	45—80
Stand 5	Big River.....	95—105	95—100	8—11	7—13	70—80	55—85

Ages were determined at stump height, or about one foot above the ground, and hereafter age will refer to age at stump height. If total age had been determined the age of spruce would probably have been increased by 5 to 10 years and that of aspen by one to two years.

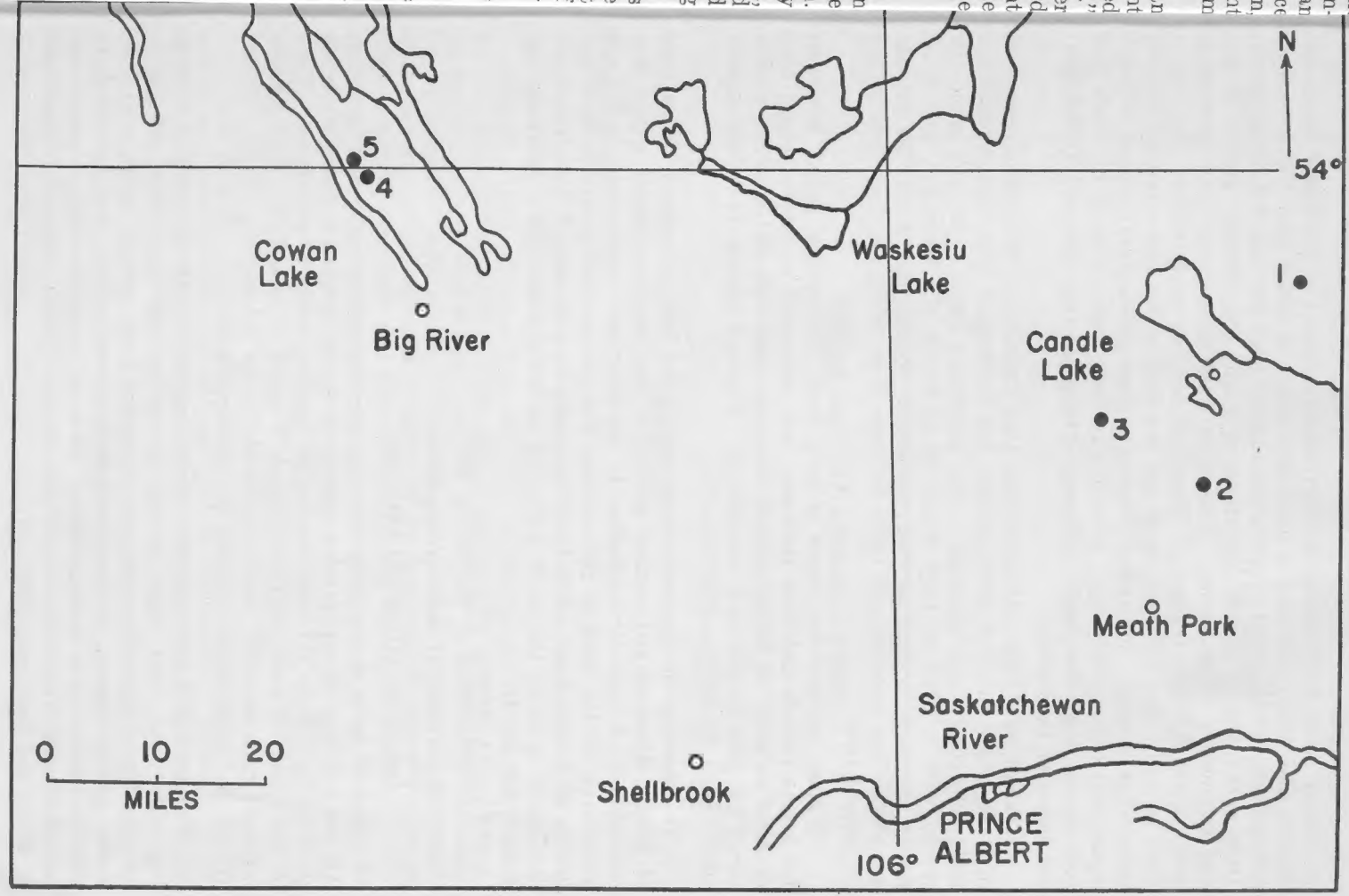

Figure 1. Map of central Saskatchewan showing location of sample areas.

METHOD OF STUDY

Study areas were chosen in which white spruce had penetrated the aspen canopy and which provided a maximum range of stand age. Spruce which had not reached the level of the aspen canopy were not included in the study. Data were taken to permit comparison of height and diameter growth of free and suppressed white spruce. Free trees were defined as those growing in small openings within the stand. They had received some sunlight from above from an early age, and had grown into the level of the aspen canopy without serious top damage. Suppressed trees were those growing near groups of larger aspen, and consequently their growth may have been retarded by shade and root competition. Many of the suppressed trees had been damaged by mechanical action of the aspen.

Ten groups of trees within each stand were measured. Each group consisted of three trees: one free white spruce, one suppressed white spruce, and the main competing aspen adjacent to the suppressed spruce. In each group the spruce were selected so they would be as nearly the same age and in as nearly the same location as was practicable. Within any stand, the average age of the free trees did not differ by more than two years from that of the suppressed trees.

A stem analysis was made of each tree. For spruce, radial increment for 5-year periods and bark thickness, both measured at breast height, were recorded as well. A height growth curve for each tree and a radial growth curve for each spruce were constructed. Figure 2 shows the height growth curves for a typical group of three trees.

To determine the degree to which spruce had been suppressed, an analysis of height, diameter and volume growth of free and suppressed spruce was carried out. A basis for replication in the experiment was sought in the age distribution of the trees in the sample. For comparative purposes three age groups of spruce were selected. (The aspen in each set of three trees was considered to be of the same age group as the spruce.) The following age groups were used:

Age Group I —55 to 60 years.

Age Group II —70 to 75 years.

Age Group III—95 to 100 years.

Most of the spruce growing in a stand were found to be in the same age group. All trees in Age Group I were located in Stand 3, Candle Lake, while all trees in Age Group III were located in Stand 5, north of Big River. Trees in Age Group II were from both Stands 1 and 2, Candle Lake. Stand 4 was not used since the trees were intermediate in age between Age Groups II and III and not required for purposes of this comparison.

Average height growth curves for each age group were obtained by averaging values read from height growth curves for individual trees. Similarly, average diameter growth curves were computed from average values read from radial growth curves. Radius-inside-bark measurements were converted to diameter-outside-bark measurements. Total cubic-foot volume of spruce was compiled using Table 150, *Form-Class Volume Tables* (Canada, Department of Mines and Resources, 1948).

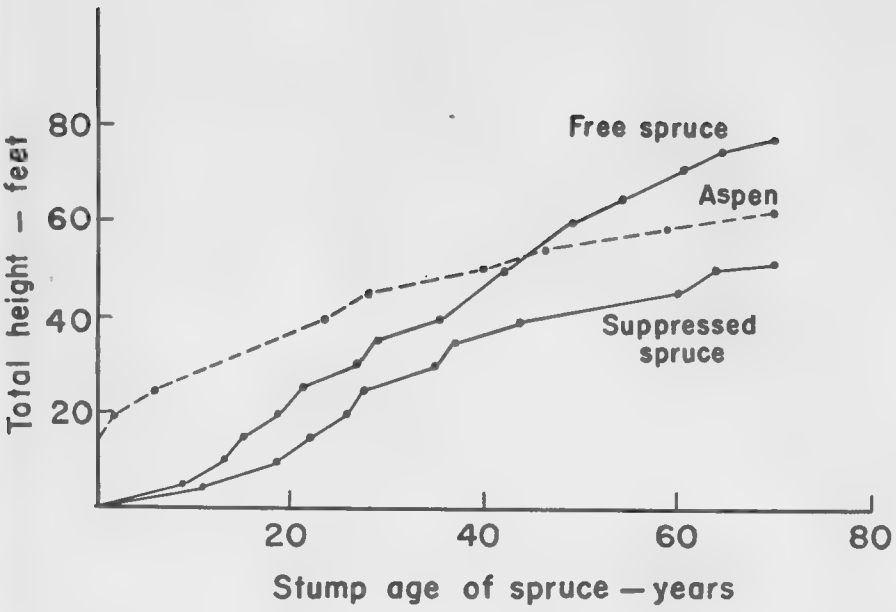

Figure 2. Height growth curves for a typical group of three trees.

RESULTS

Height Growth

Average height growth curves for aspen and white spruce for each of the three age groups are shown in Figure 3.

Height growth of aspen exceeded that of free spruce for the first three decades, and that of the suppressed spruce for the first three to four decades. Maximum height growth of both free and suppressed spruce occurred between 10 and 20 years. At ages above 50 or 60 years, height growth of suppressed spruce tended to approach and occasionally surpass that of free spruce, as in Age Group III between 90 and 100 years (indicated by slopes of curves).

In all three age groups, free spruce overtopped aspen when between 40 and 65 years of age. In none of the age groups had suppressed spruce become taller than aspen, although in Age Group I it seemed probable that they might when between 60 and 70 years of age. In Age Group III, suppressed spruce averaged 10 feet shorter than aspen at 100 years of age.

Site differences were probably responsible in part for differences in height-growth/age relationships between age groups (Figure 3). However, such differences in site as existed did not appreciably alter the comparative height growth relationships between aspen and spruce.

The time required to grow to breast height from stump height was 7.1 years for the average free white spruce and 8.7 years for the average suppressed white spruce. The difference between means (1.6 years) was statistically significant. Thus the effect of aspen on the white spruce began when the spruce were very young.

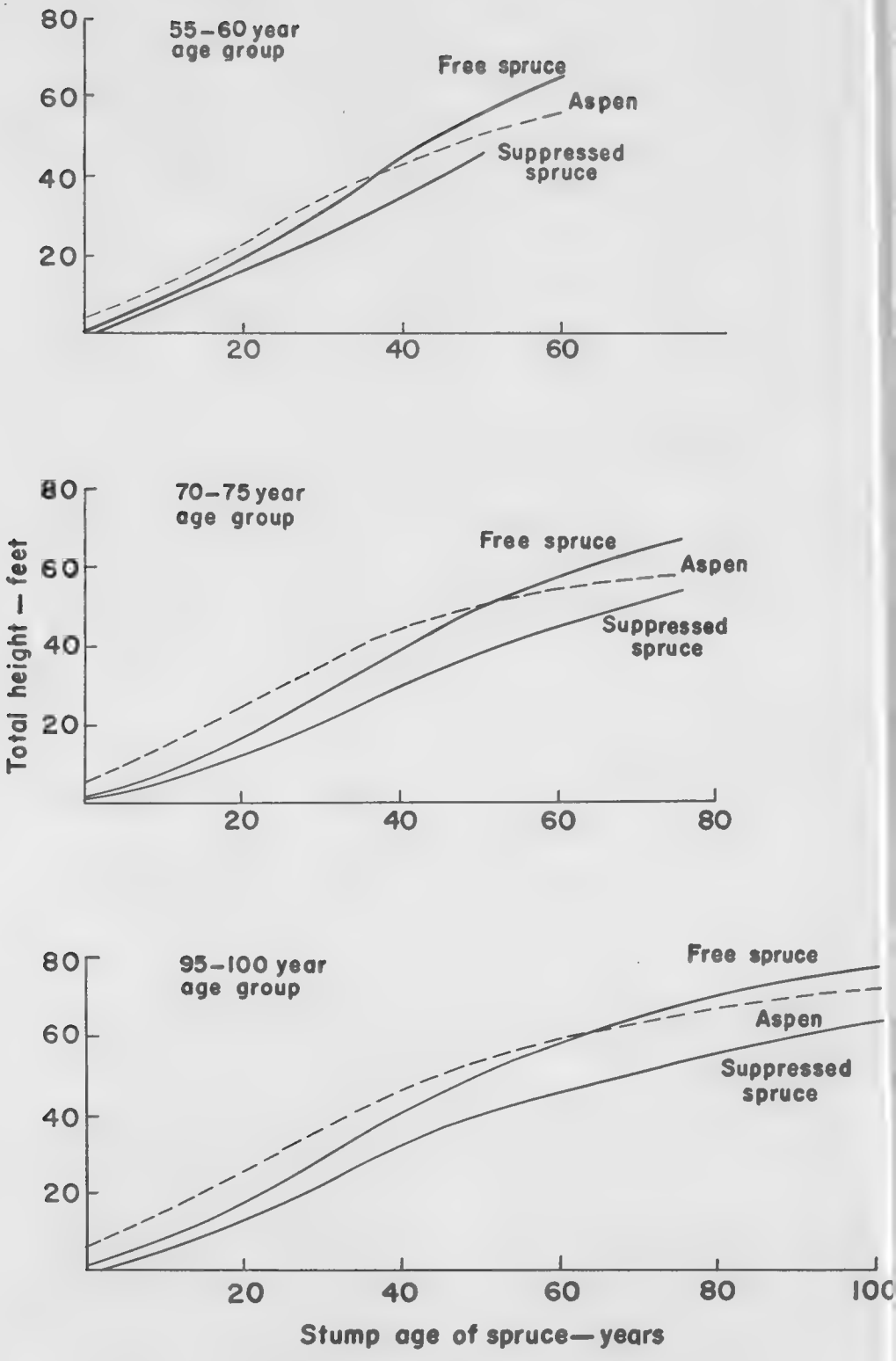

Figure 3. Average height growth curves for aspen and white spruce.

Diameter Growth

Curves of average diameter growth at breast height for free and suppressed spruce for each of the three age groups are shown in Figure 4.

Diameter growth of free spruce usually exceeded that of suppressed spruce, although in Age Group III between 80 and 100 years they were about the same, as shown by curve slopes. Maximum diameter growth of both free and suppressed spruce occurred between 10 and 30 years. Thereafter diameter growth of free spruce gradually decreased. However, that of suppressed spruce in Age Groups II and III showed slight increases at older ages, probably as a result of lessening competition as the aspen component in the forest deteriorated.

Volume

Table 2 shows average total volume in cubic feet for free and suppressed spruce within each age group and also volume of suppressed trees expressed as a percentage of free-growing trees. Volumes of suppressed spruce were approximately half the volumes of corresponding free spruce.

TABLE 2.—TOTAL VOLUME (CUBIC FEET), FREE AND SUPPRESSED SPRUCE

Age Group	Total volume per tree		Volume of suppressed as percentage of free
	Free spruce	Suppressed spruce	
I 55—60	11.1	6.0	54
II 70—75	17.7	9.0	51
III 95—100	19.8	10.8	54

Form

Suppressed trees usually were poorly formed. Many stems had sweep, crook, and forked tops, which increase waste in sawing and lower lumber quality.

DISCUSSION

The results have been the outcome of a highly subjective method of selecting sample trees, but they nevertheless show that up to 100 years of age suppressed white spruce were retarded in diameter, height and volume growth by an aspen overstory.

While the present economic positions of aspen and white spruce remain relatively unchanged, some form of silvicultural treatment to release suppressed spruce would appear to be warranted. As it has been shown that spruce may become suppressed at an early age, release of the spruce understory as soon as it is well established should produce the maximum silvicultural benefits. It is realized that this treatment might cause losses and damage in the white spruce understory because of changed environment and competition from aspen sprouts and other underbrush. Possibly as an alternative the aspen might be removed at 40 to 50 years of age when a sufficient return can be realized from it through utilization for either pulpwood or plywood.

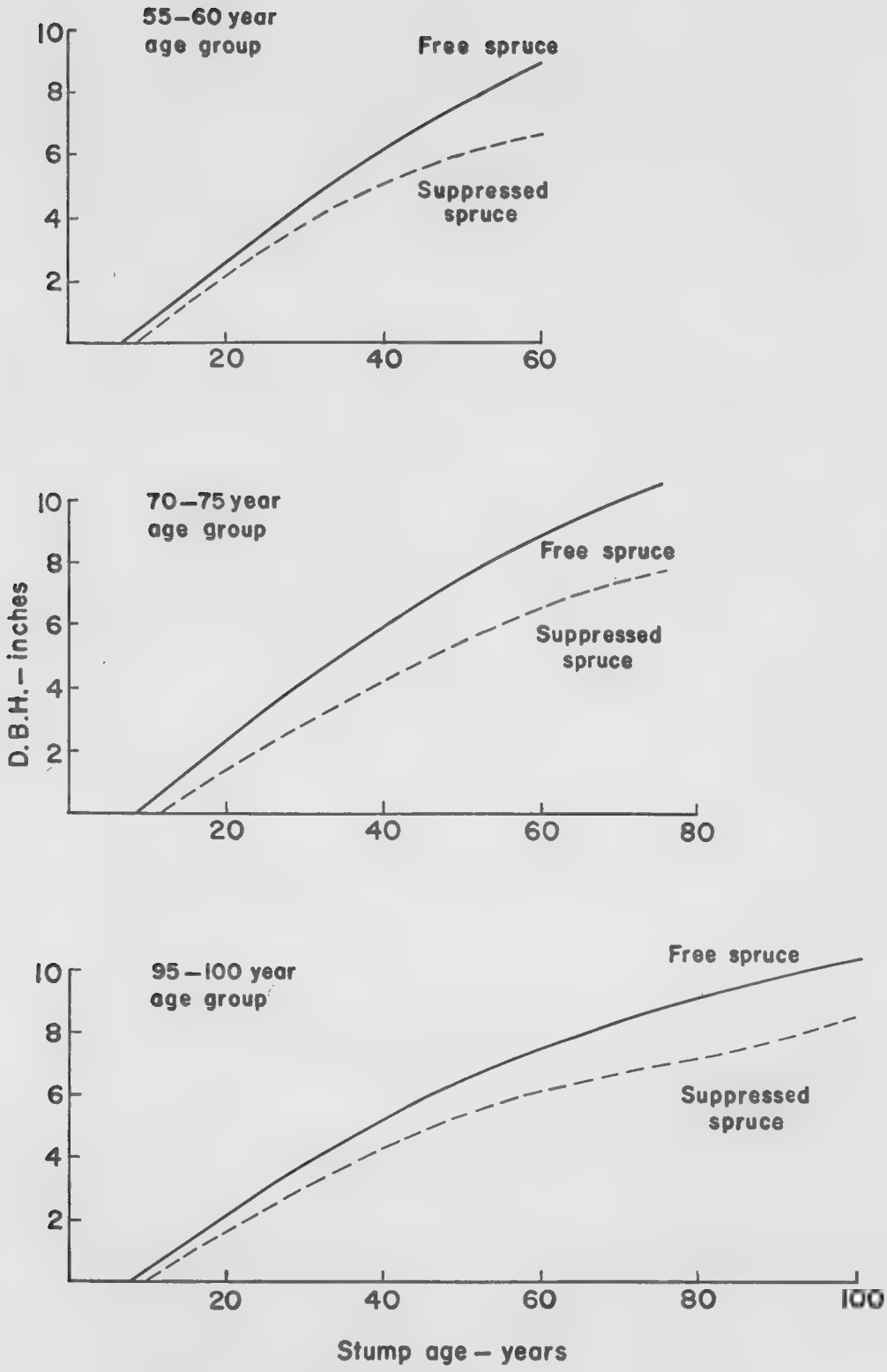

Figure 4. Average diameter growth curves for white spruce.

SUMMARY

A study was carried out in five mixed stands of aspen and white spruce in Saskatchewan to determine the effect of the aspen overstory on the white spruce understory. Height, diameter and volume growth of free and suppressed spruce were examined after the data had been sorted into three age groups based on the age of the spruce. Results are presented which, although dependent upon a subjective selection of trees, do indicate that large differences in growth between free and suppressed spruce may occur. The findings are summarized as follows:

(1) In young and intermediate-aged white spruce—aspen stands, an aspen overstory may by suppression considerably reduce the height and diameter growth of white spruce. On stands up to 100 years of age it may reduce their volume by as much as 50 per cent as compared with that of nearby free-growing white spruce of the same age.

(2) White spruce trees suppressed by aspen may be expected to take longer to reach breast height, and eventually to overtop the aspen, than free-growing ones.

(3) An aspen overstory will lower the quality of the white spruce which it suppresses by damaging leaders as a result of whipping and by causing such commonly found defects as forked top, crook, and sweep.

It is suggested that silvicultural treatments such as releasing the white spruce understory as soon as it has become well established, or alternatively releasing it at 40 to 50 years of age if a sufficient return can be realized from the aspen, may be warranted.

A number of experimental cuttings have recently been made involving the release of white spruce by the removal of aspen in stands of different ages. Results will be reported as they become available.

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